Method and device for intensifying the permeability of ground layers close to boreholes and of filter bodies and filter layers in water wells and other production wells

The invention relates to a method and a device by means of which the permeability of ground layers close to boreholes and of filter bodies and filter layers introduced into the borehole in water wells and other production wells can be intensified.

In water wells and other production wells, solids and encrustations are deposited during operation in ground layers close to the borehole and in filter bodies and filter layers introduced into the borehole. These encrustations increasingly impair permeability to the liquid medium to be extracted.

Various methods and devices for counteracting the resulting decrease in production are known from the prior art.

The German patent DE 195 37 689 C2, for example, describes a well regeneration method in which a cylindrical body is lowered between two wire pulleys acting as centering means into a well. By opening a valve in this cylindrical body, a highly pressurised gas is blown against the wall of the well. This gas impinges on the wall of the well as a pulsating pressure wave. The valve opening times, the volume of gas released and the gas pressure can be set before commencement of the well regeneration work.

The disadvantage of this method is that during well regeneration work, it does not allow any concurrent and immediate adjustment of the gas pressure, gas volume and valve opening times to suit the hydraulic properties of the well and the surrounding ground as they change with each pulse of gas, and that the valve is not opened by a signal at an exactly defined point in time. Moreover, the specified pressure of 10 to 25 bar does not guarantee

any great depth of penetration into the ground layers close to the borehole and requiring regeneration, or into the filter bodies and filter layers.

The DE 199 32 593 C1 describes another method, in which at least one vertical working section that is partitioned off from the rest of the borehole by two packer elements is charged with a pulsating gaseous or liquid pressure medium. Any water and/or the pressure medium is pressed through the filter walls into the surrounding filter gravel layers. A pressure vessel that serves as a buffer store is provided in the immediate vicinity of the working section in order to prevent pressure losses in the pressure lines.

The principle by which a regeneration effect is obtained with this method consists in the action of a pulsating gaseous or liquid pressure medium on the working section and the resulting pressing of well water and/or pressure medium through the screen slots into the filter gravel layers; in other words, the principle consists merely in displacing a volume through the screen slots.

Another method is proposed in the patent application DE 198 43 292.5, according to which the sudden decompression of a compressed gas or pressurised liquid generates pulses in the well. On account of the sluggish material used in the counter-pressure chamber, the device used in this method opens and closes too slowly to generate a kinetic energy pulse. Plus, with this method too, the regeneration effect consists merely in a pressure-alternating volume displacement.

Finally, a well regeneration method is known in which pressure pulses are generated by means of explosive charges. Use of this method is by no means possible in every well since the pressure pulses generated, being very energy-intensive and practically impossible to control, can lead to destruction of the well lining.

All the known methods are based on the common principle of pressing the well medium or a foreign medium through the screen slots into the surrounding filter and/or ground layer by means of brief, sometimes pulsating volume

displacement in the suction zone of the production well. The necessary volume displacement is effected by the release – which differs in speed from process to process – of a usually fairly large volume of a pressurised foreign medium (industrial gas, explosive gas, liquid).

With the known methods, the principle of volume displacement limits the range of action into the borehole surroundings, since, as is known, the compressibility of liquids is low. Only when an explosive is used is an energy pulse generated in the liquid due to the very high speed at which the explosive reacts chemically. The energy pulse generated in this method makes for a long action range, but at the same time, the reaction is so fast that it produces a very "hard" pulse, and this, in turn, constitutes a high risk to the borehole and the well lining.

The object of the invention is thus to provide a method and a device for intensifying the permeability of ground layers close to boreholes and of filter bodies and filter layers in water wells and other production wells, which makes it possible to intensify the permeability of ground layers close to boreholes and of filter bodies and filter layers more efficiently than is possible with methods and devices known from the prior art, and without any risk of destroying the borehole and its linings.

As far as the method is concerned, this object is established by the characterizing features of claim 1, and as far as the device is concerned, by the characterizing features of claim 7.

Useful embodiments of the method form the features of the sub-claims 2 to 6, while useful embodiments of the device form the features of the claims 8 to 11.

The invention will now be explained in more detail on the basis of preferred embodiments and by reference to the Figures 1 to 3.

Fig. 1 is a schematic diagram showing a longitudinal section through a production well with a device according to the invention suspended therein;

Fig. 2 shows details of the structure of a device used to carry out the method of the invention;

Fig. 3 shows, in a view similar to that of Fig. 1, a production well with a modified device according to the invention suspended therein.

With the method of the invention and the associated device, a very small volume of liquid that is subjected to kinetic energy pulses which, as a rule, are of very high intensity, is used to generate a hydraulic energy pulse E in the extraction area F of the production well 11 under parameters that can be precisely monitored and controlled by instrumentation. The energy pulse E is reinforced in its effectiveness by a dynamic current generated continuously by an underground pump 8. As seen in Figs. 1 to 3, a surface pressure unit 6 presses a liquid (in the case of a water well, for example, water from this well) under high pressure (up to 150 bar) into a pressure line 2 at the end of which is a pulse generator 1 provided with a large-area valve that is able to open and close again within 1 to 2 milliseconds and, within this very short time, to release a very small, exactly pre-defined volume of the highly pressurised liquid (about 300 ml) into the liquid to be extracted, e.g. the surrounding well water. On account of the small volume used, the effect of the volume displacement is minor; of much greater significance is the fact that the violent impact of the small liquid volume released with high kinetic energy makes the well-water molecules oscillate, and the hydraulic energy pulse E generated as a result propagates on account of the physical phenomenon as a pulse flow through the screen slots and into the liquid surrounding the production well 11. This oscillation of the liquid molecules causes encrustations on the inside and the outside of

the screen to detach at their respective locations, and fine-grained material, for example, to move out of the filter-gravel wall.

Since the method provides for simultaneous generation of a dynamic current in the production well 11 and its surroundings by continuous, controllable pumping away of liquid by means of an underground pump 8, all matter removed from its previous location by the hydraulic energy pulse E is pumped away immediately.

Continuous pumping away is made possible by the fact that the method of the invention uses tiny volumes of liquid, so that no rising gas bubbles are generated. During well regeneration, the pulse generator 1 is moved in defined manner up and down inside the borehole 7 in the extraction area F by means of a hose reel 5.

The control signal for opening the valve of the pulse generator 1 is transmitted as an electrical signal from the control unit 9 via a control cable 4 to the pulse generator 1.

The electromagnet 14 is energized momentarily by the control signal, and the valve disk 16 opens the working chamber 12. The liquid previously impounded here and provided with kinetic energy escapes within 1 to 1.5 milliseconds through the outflow apertures 13 into the surrounding liquid to be extracted.

The energizing of the electromagnet 14 simultaneously causes the lower valve disk 17 to be pushed downwards against the pressure of a liquid in the valve-closing chamber 15. Immediately after the pressure reduction of the volume in the working chamber 12, the pressure prevailing in the valve-closing chamber 15 forces the lower valve disk 17 abruptly back again in the opposite direction, thus closing the valve 13 again after about 2 to 2.5 milliseconds. Both the amount and the pressure of the liquid volume contained in the valve-closing chamber 15 may be varied via a closing valve 18 actuated by the control unit 9.

The volume of the working chamber 12 may likewise be varied under operating conditions by way of the control unit 9. This means that the physical parameters of the device and thus the intensity of the kinetic energy pulse E that is generated can be adapted to all variants of production wells 11 and their diameters. There are no limitations regarding the depth at which the method can be implemented in the production wells 11.

Mounted on the pulse generator 1 is a sensor 10 that continuously registers the energetic and time-dependent characteristics of the energy pulses E and transmits them via an instrument lead 3 to the control unit 9 at the surface. Here, on the basis of the pulse action characteristics registered by the sensor 10, of changes in the dynamic water level in the production well 11 and of changes registered at the pump outflow point in the discharge of dissolved colmatants, the operator is able to control the working pressure of the liquid in the pulse generator 1 and the delivery volume of the underground pump 8.

Thanks to the parameters determined by means of the sensors 10, the method of the invention can be controlled precisely and is thus able, during the regeneration of a production well 11, to continuously adjust itself precisely to the conditions of the producing well's hydraulic system as they change during the course of the regeneration work. No interruption in the regeneration process is necessary.

In addition, on account of the complex measurability and controllability of its physical parameters, the method of the invention can be adapted to every known well lining of the production well 11.

If the filter material is very brittle, as is the case, for example, with stoneware or aged PVC, the hydraulic energy pulses must have only a low energy content so as to ensure that in this case, too, the brittle materials are neither damaged nor destroyed. If, in addition to the filter

material being very brittle, it contains a particularly large quantity of colmatage (e.g. due to an extended period of operation without regeneration, or to an extremely high iron content in the medium being extracted), regeneration will take a long time on account of the low energy content of the pulses. Alternatively, if regeneration work is limited to a justifiable period of time, the permeability of the filter bodies, the filter layers and of ground layers close to the borehole will not be intensified to the desired degree.

In this case, the method and the device of the invention are modified in the manner illustrated in Fig. 3 and described below.

The production well 11 illustrated in Figure 3 is a water well for supplying drinking water.

To start with, work proceeds in the previously described manner on the well to be regenerated. Since the screen W – shown in section schematically as a dashed line in Fig. 3 – of the well to be regenerated consists of very brittle material, the energy for the hydraulic energy pulses is selected to be very low so as to ensure the prevention of any damage to the screen W. The very low energy input would considerably prolong the regeneration work. If, in addition, the filter layers contain a particularly large quantity of colmatage, which can happen if the well is operated for too long without regeneration or if the ground water has a very high iron content, it is possible that at the low energy-input level, the regeneration work will take a disproportionately long time or, if regeneration has to be completed within a justifiable period of time, that the filter layers will not be freed entirely of colmatants.

In such cases, therefore, the previously described method is discontinued or interrupted once the internal surfaces have been cleaned and the apertures in the screen W have been unclogged. The pulse generator 1 and the underground pump 8 are temporarily withdrawn from the production well 11, and the pulse generator 1 is provided at its

upper and lower ends with packer disks P that correspond with the internal diameter of the screen W installed in the production well 11. The pulse generator 1 provided with the packer disks P is then lowered to a terminal section of the screen W, and, by means of the pressure unit 6, a regenerating liquid, e.g. one that is commercially available, is pulsed or pressed via the pressure hose 2 and the pulse generator 1 with weak energy pulses E through the now unclogged apertures in the screen W into the surroundings of the production well 11, i.e. in the case of water-well regeneration, into the aquifer A. This procedure is repeated successively in sections corresponding approximately to the distance between the packer disks P on the pulse generator 1 until the other end of the screen W is reached. The pulse generator 1 along with the packer disks P attached to it is then withdrawn again from the production well 11, and the underground pump 8 is lowered into the production well 11again. After the regenerating liquid has been allowed to act for a defined period, the underground pump 8 is restarted and the regenerating liquid is pumped out completely, along with the dissolved colmatants. This operation is followed, as is standard practice following a well regeneration process, by intensive water withdrawal.

To intensify the cleaning effect of the above-described modified process of the invention, the packer disks P are detached again from the pulse generator 1 following the process of pulsing and pressing in of regenerating liquid and subsequent renewed withdrawal of the pulse generator 1 and the underground pump 8 from the production well 11; the pulse generator 1 and the underground pump 8 are then lowered once more into the production well, and the regeneration fluid allowed to act for a defined period while the pulse generator 1 moves to and fro and simultaneously emits successive, weak, hydraulic energy pulses. The regenerating liquid is subsequently pumped out completely, along with the dissolved colmatants, by means of the underground pump 8.

By virtue of the two last-mentioned modified embodiments of the invention, the method of intensifying the permeability of ground layers close to

boreholes and of filter bodies and filter layers in the underground extraction areas of water wells and other production wells is particularly suitable for the regeneration of water wells with especially brittle screens, e.g. of stoneware or of aged PVC, where, in addition, the filter layers contain a particularly large quantity of colmatage.